

APPENDIX A

S-RECORD INFORMATION

INTRODUCTION

The S-record format for output modules was devised for the purpose of encoding programs or data files in a printable format for transportation between computer systems. The transportation process can thus be visually monitored and the S-records can be more easily edited.

S-RECORD CONTENT

When viewed by the user, S-records are essentially character strings made of several fields which identify the record type, record length, memory address, code/data, and checksum. Each byte of binary data is encoded as a 2-character hexadecimal number: the first character representing the high-order 4 bits, and the second the low-order 4 bits of the byte.

The 5 fields which comprise an S-record are shown below:

TYPE	RECORD LENGTH	ADDRESS	CODE/DATA	CHECKSUM
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where the fields are composed as follows:

<u>FIELD</u>	<u>PRINTABLE CHARACTERS</u>	<u>CONTENTS</u>
Type	2	S-record type - S0, S1, etc.
Record length	2	The count of the character pairs in the record, excluding the type and record length.
Address	4, 6, or 8	The 2-, 3-, or 4-byte address at which the data field is to be loaded into memory.
Code/data	0-2n	From 0 to n bytes of executable code, memory loadable data, or descriptive information. For compatibility with teletypewriters, some programs may limit the number of bytes to as few as 28 (56 printable characters in the S-record).
Checksum	2	The least significant byte of the one's complement of the sum of the values represented by the pairs of characters making up the record length, address, and the code/data fields.

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Each record may be terminated with a CR/LF/NULL. Additionally, an S-record may have an initial field to accommodate other data such as line numbers generated by some time-sharing systems.

Accuracy of transmission is ensured by the record length (byte count) and checksum fields.

S-RECORD TYPES

Eight types of S-records have been defined to accommodate the several needs of the encoding, transportation, and decoding functions. The various Motorola upload, download, and other record transportation control programs, as well as cross assemblers, linkers, and other file-creating or debugging programs, utilize only those S-records which serve the purpose of the program. For specific information on which S-records are supported by a particular program, the user manual for that program must be consulted.

NOTE

The EVM monitor supports only the S1 and S9 records. All data before the first S1 record is ignored. Thereafter, all records must be S1 type until the S9 record terminates data transfer.

An S-record format module may contain S-records of the following types:

- | | |
|-------|--|
| S0 | The header record for each block of S-records. The code/data field may contain any descriptive information identifying the following block of S-records. The address field is normally zeroes. |
| S1 | A record containing code/data and the 2-byte address at which the code/data is to reside. |
| S2-S8 | Not applicable to EVM. |
| S9 | A termination record for a block of S1 records. The address field may optionally contain the 2-byte address of the instruction to which control is to be passed. If not specified, the first entry point specification encountered in the object module input will be used. There is no code/data field. |

Only one termination record is used for each block of S-records. Normally, only one header record is used, although it is possible for multiple header records to occur.

S-RECORD CREATION

S-record format programs may be produced by several dump utilities, debuggers, or several cross assemblers or cross linkers. Several programs are available for downloading a file in S-record format from a host system to an 8-bit or 16-bit microprocessor-based system.

S-RECORD EXAMPLE

Shown below is a typical S-record format module, as printed or displayed:

```
S00600004844521B
S1130000285F245F2212226A000424290008237C2A
S11300100002000800082629001853812341001813
S113002041E900084E42234300182342000824A952
S107003000144ED492
S9030000FC
```

The above module consists of an S0 header record, four S1 code/data records, and an S9 termination record.

The S0 header record is comprised of the following character pairs:

S0	S-record type S0, indicating a header record.
06	Hexadecimal 06 (decimal 6), indicating six character pairs (or ASCII bytes) follow.
00 00	Four-character 2-byte address field, zeroes.
48 44 52	ASCII H, D, and R - "HDR".
1B	Checksum of S0 record.

The first S1 code/data record is explained as follows:

S1	S-record type S1, indicating a code/data record to be loaded/verified at a 2-byte address.
13	Hexadecimal 13 (decimal 19), indicating 19 character pairs, representing 19 bytes of binary data, follow.
00	Four-character 2-byte address field; hexadecimal address 0000, indicates location where the following data is to be loaded.

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The next 16 character pairs are the ASCII bytes of the actual program code/data. In this assembly language example, the hexadecimal opcodes of the program are written in sequence in the code/data fields of the S1 records:

<u>OPCODE</u>	<u>INSTRUCTION</u>	
28 5F	BHCC	\$0161
24 5F	BCC	\$0163
22 12	BHI	\$0118
22 6A	BHI	\$0172
00 04 24	BRSET	0, \$04, \$012F
29 00	BHCS	\$010D
08 23 7C	BRSET	4, \$23, \$018C

. (Balance of this code is continued in the code/data fields of the
 . remaining S1 records, and stored in memory location 0010, etc..)
 .

2A Checksum of the first S1 record.

The second and third S1 code/data records each also contain \$13 (19) character pairs and are ended with checksums 13 and 52, respectively. The fourth S1 code/data record contains 07 character pairs and has a checksum of 92.

The S9 termination record is explained as follows:

S9 S-record type S9, indicating a termination record.

03 Hexadecimal 03, indicating three character pairs (3 bytes) follow.

00 Four-character 2-byte address field, zeroes.

00

FC Checksum of S9 record.

Each printable character in an S-record is encoded in hexadecimal (ASCII in this example) representation of the binary bits which are actually transmitted. For example, the first S1 record above is sent as shown below.

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TYPE				LENGTH				ADDRESS								CODE/DATA								CHECKSUM																													
S				1				0				0				2				8				5				F				...				2				A													
5		3		3		1		3		1		3		3		3		0		3		0		3		0		3		2		3		8		3		5		4		6		...		3		2		4		1	
0101	0011	0011	0001	0011	0001	0011	0011	0011	0000	0011	0000	0011	0000	0011	0000	0011	0010	0011	1000	0011	0101	0100	0110	...	0011	0010	0100	0001																									